

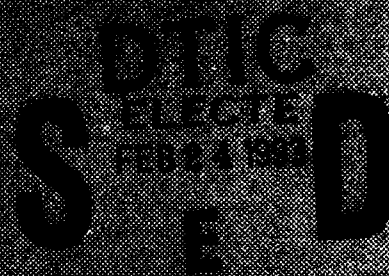


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**National PDES Testbed  
Report Series**

An Introduction to  
the NIST PDES  
Toolkit



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## National PDES Testbed



# An Introduction to the NIST PDES Toolkit

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# **An Introduction to The NIST PDES Toolkit**

**Stephen Nowland Clark**

## **1 Introduction**

The PDES (Product Data Exchange using STEP) activity is the United States' effort in support of the Standard for the Exchange of Product Model Data (STEP), an emerging international standard for the interchange of product data between various vendors' CAD/CAM systems and other manufacturing-related software [Smith88]. A National PDES Testbed has been established at the National Institute of Standards and Technology to provide testing and validation facilities for the emerging standard. The Testbed is funded by the CALS (Computer-aided Acquisition and Logistic Support) program of the Office of the Secretary of Defense.

The PDES specification consists of an information model written in the Express language [Schenck89]. This model, or conceptual schema, defines the various types of objects (entities) which can be manipulated by PDES applications. The exchange medium for actual PDES product models is the STEP physical file [Altemueller88]. A STEP physical file contains instances of the various entities defined by the PDES conceptual schema; collectively, these entity instances describe a single product.

As part of the testing effort, NIST is charged with providing a software toolkit for manipulating PDES data. This NIST PDES Toolkit, which is in the Public Domain, is an evolving, research-oriented set of software tools. Although it is fairly stable and in daily use at NIST, the Toolkit is not intended to be the basis for commercial-quality PDES implementations. This report briefly describes each of the currently available components of the Toolkit, and provides references to other documents for detailed information on each.

## **2 Components of the Toolkit**

At the core of the NIST PDES Toolkit are the Express and STEP Working Forms: software libraries for manipulating Express information models and STEP product models, respectively. A Working Form is a software library consisting of three components. The fundamental pieces are a set of C language data structures which represent the objects in the Working Form's domain and a set of primitive access functions for manipulating these data structures. In addition, each Working Form includes a parser which is built on top of the primitive access functions. These parsers read Express or STEP source files and create the Working Form representation of the model found.

In addition to the Working Form libraries, the Toolkit includes several prototype applications based on these libraries. These applications include several translators (e.g., Express to Oracle<sup>®</sup> schema translator, STEP to Smalltalk-80<sup>™</sup> translator), as well as QDES, a prototype STEP model editor. In addition to being useful in their own right, these applications can serve as examples to aid in the construction of new applications using the Toolkit. Often (as in the Toolkit), such translators will occur in pairs: a Fed-X-based Express translator, which translates information models for a particular application; and a STEPparse-based STEP translator, which takes care of individual product models for the application.

With the exception of QDES, which is implemented in the Smalltalk-80 programming language/environment [Goldberg85], the Toolkit is implemented in ANSI Standard C [ANSI89]. Common technical issues and the structure of the Toolkit software are discussed in [Clark90c].

## 2.1 Fed-X and the Express Working Form

The Express Working Form [Clark90a] is a software library for manipulating Express language information models. In addition to a comprehensive set of data structures for representing these models, the Working Form includes an Express parser, Fed-X, which reads an Express source file and instantiates these data structures. It is a straightforward task to add an output generation pass to Fed-X, creating an Express translator. This process is described in [Clark90d].

Fed-X is intended to drive the various components of a PDES implementation. Applications can insulate themselves from knowledge of Express and from knowledge of any particular schema by relying on Fed-X and the Working Form to provide them with this knowledge. An example of this reliance is found in the QDES model editor (described in section 2.3). QDES itself is independent of any particular data model. It expects a file which defines the conceptual schema in a particular format (namely, Smalltalk-80 source code), and uses this file to determine what types of objects it will manipulate. This form of the conceptual schema is produced by a Fed-X-based Express translator, Fed-X-QDES.

## 2.2 STEPparse and the STEP Working Form

The STEP Working Form [Clark90b] is a software library for manipulating PDES product models. This library includes a parser, STEPparse, which reads a product model from a STEP physical file and builds the corresponding Working Form representation. An output-generation back end can be added to STEPparse to build a STEP translator. For more information, see [Clark90e].

The STEP Working Form is an example of a piece of schema-independent software which relies on the Express Working Form as a data dictionary. It is isolated from any knowledge of Express or of any particular information model. Pieces of the Express Working Form are used to interpret the contents of STEP physical files and of instantiated objects in the STEP Working Form.

The STEP Working Form can be used by PDES applications as the underlying representation for product models. These applications then need not worry about Express or STEP, or about the underlying representation of the models they manipulate. Alternatively, STEPparse can be used to build a translator which translates STEP physical files into the particular format required by some application. Existing applications can then use PDES models without actually being built on top of the Working Form, and without concerning themselves with STEP physical files.

## 2.3 QDES: The Model Editor

The Quick 'n' Dirty Editor for STEP (QDES) is an editor for manipulating STEP product models [Clark90f] [Clark90g]. Written in Smalltalk-80, it is window-based and is driven by an Express information model through Fed-X-QDES. QDES allows an instantiated model to be browsed, following attribute relationships in the product model as well as sub- and supertype relationships in the information model. In addition, it is possible to modify existing objects in the product model and to add new entity instances.

As mentioned above, QDES is completely decoupled from the data it manipulates. It has no *a priori* knowledge of any conceptual schema; instead, a file containing Smalltalk-80 class definitions corresponding directly to the entities in an Express schema is loaded into QDES. The editor then uses these class definitions to define its domain and the structure of the objects in this domain.

The Smalltalk-80 class definitions used by QDES are generated by a translator, Fed-X-QDES, which is included with the Toolkit. This Express-to-Smalltalk translator was created by defining an output module to generate Smalltalk class definitions and plugging this module in as the back end to the Fed-X parser. Similarly, a STEP-to-Smalltalk translator, STEPparse-QDES, is packaged with the Toolkit. This translator produces Smalltalk-80 object instantiations from a STEP physical file. The resulting file can then be loaded into QDES, edited, and saved as a STEP physical file.

## 2.4 SQL Database Tools

Two applications to support relational databases are provided with the NIST Toolkit. These tools use Structured Query Language (SQL) [ANSI86] for database transactions. Both tools are used to support NIST's Oracle database for PDES.

Fed-X-SQL, the Express-to-SQL translator, defines and populates a data dictionary and produces SQL statements to generate a relational database based on an Express schema [Morris90]. The mapping from Express to SQL used by this translator is described in [Metz89].

Once a database has been defined using Fed-X-SQL, a product model stored in a STEP physical file can be loaded into this database using the STEPwf-SQL database loader [Nickerson90]. STEPwf-SQL is not, strictly speaking, a translator: rather than producing an output file, it loads a product model from a STEP physical file directly into an Oracle database. Nevertheless, the loader is built like a typical STEPparse-based translator: an output module is plugged in as the back end of STEPparse.

### 3 How It All Fits Together: A Sample Application

QDES is an example of an application which relies on the NIST PDES Toolkit without actually directly calling any Toolkit software. It is anticipated that PDES implementation environments will wish to make use of existing software, which has not been written for use with PDES, Express, or STEP. The approach taken in QDES is appropriate to this situation, and we examine it here to demonstrate how the pieces of the Toolkit work together. Figure 1 shows the various pieces of software which are connected with QDES.

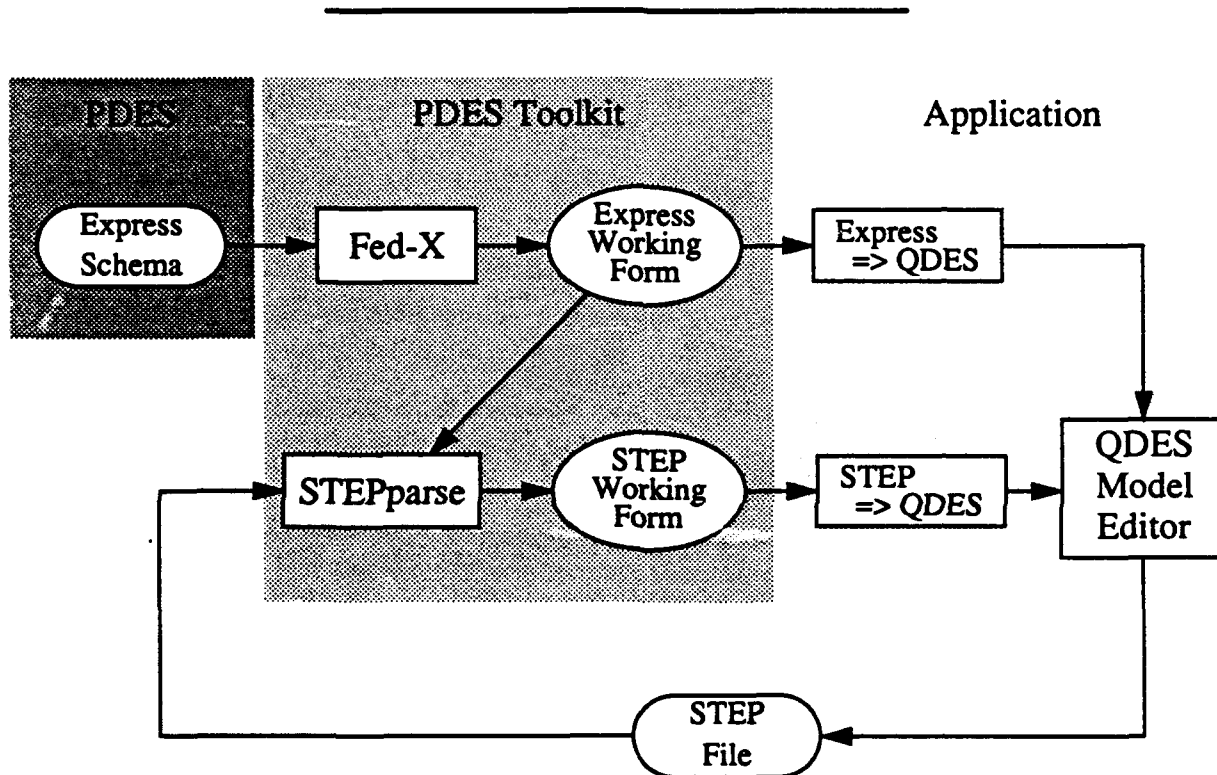


Figure 1: Architecture of a Typical Toolkit Application

The Fed-X parser builds Express Working Form data structures from an Express source file. An Express-to-QDES report generator uses these data structures to produce Smalltalk class definitions for QDES. It is this data flow which allows QDES to be written as a schema-independent application.

A second, parallel data flow is used to load an actual product model from a STEP physical file into QDES. To begin this process, STEPparse reads the product model and, referring to the Express Working Form structures built by Fed-X, builds an instantiated STEP Working Form model. A STEP-to-QDES report generator then translates these Working Form structures into Smalltalk object instantiations, which can be loaded into QDES.

This general architecture is appropriate for many applications which need to use PDES information models and product models, but which must use proprietary or other special input formats for these models. In order to replace QDES with a new application in this architecture, all that is necessary is to provide Fed-X and STEPparse output modules to replace the Express-to-QDES and STEP-to-QDES modules shown.

## **4 Status and Availability**

The NIST PDES Toolkit is an evolving research toolkit. The basic functionality and architecture are fairly stable: there will always be an Express parser, a STEP parser, working forms, and some sort of model editing tool; but implementations, programming languages, and specific features are likely to change as the software evolves. In particular, QDES is very clearly a prototype editor. Although it is used on a daily basis in the National PDES Testbed, there is a clear need for one or more new editors to replace it. Also, some language features remain unimplemented in the Express and STEP Working Forms. These missing features are described in [Clark90a] and [Clark90b].

For further information on the Toolkit and its current status, or to obtain a copy of the software, use the attached order form.



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- ☐ Clark, S.N., An Introduction to The NIST PDES Toolkit
- ☐ Clark, S.N., The NIST PDES Toolkit: Technical Fundamentals
- ☐ Clark, S.N., Fed-X: The NIST Express Translator
- ☐ Clark, S.N., The NIST Working Form for STEP
- ☐ Clark, S.N., NIST Express Working Form Programmer's Reference
- ☐ Clark, S.N., NIST STEP Working Form Programmer's Reference,
- ☐ Clark, S.N., QDES User's Guide
- ☐ Clark, S.N., QDES Administrative Guide
- ☐ Morris, K.C., Translating Express to SQL: A User's Guide
- ☐ Nickerson, D., The NIST SQL Database Loader: STEP Working Form to SQL
- ☐ Strouse, K., McLay, M., The PDES Testbed User's Guide

OTHER (PLEASE SPECIFY)

These documents and corresponding software will be  
available from NTIS in the future. When available, the  
NTIS ordering information will be forthcoming.

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11. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY OR LITERATURE SURVEY, MENTION IT HERE.) <p>The Product Data Exchange Specification (PDES) is an emerging standard for the exchange of product information among various manufacturing applications. A software toolkit for manipulating PDES data has been developed at the National PDES Testbed at NIST. This toolkit includes software for processing PDES information models, defined in the Express language, and PDES product models, stored as STEP physical files. The components of this NIST PDES Toolkit are discussed, as are several applications which have been built using the Toolkit.</p>				
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